Evaluation of

Calpuff Model Performance

Using Year 2000 Data

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Introduction

Performance of the Calpuff model (Version 5.4, Level 000602_1), as implemented by the North Dakota Department of Health (NDDH) for Year 2000 data, was evaluated using SO_2 observations from the NDDH Dunn Center and Theodore Roosevelt National Park (TRNP) South Unit monitoring sites. Meteorological input data for Calpuff were developed using the Calmet meteorological model (Version 5.2, Level 000602a). Source emission rates were based on CEM's hourly data (where available) or annual average emission for Year 2000.

The performance evaluation proceeded in an iterative manner to determine the effect of adjustments to settings in the Calmet and Calpuff input control files on model skill. The majority of these settings were left equivalent to recommendations in "IWAQM Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts," 1998. But changes to a limited number of settings were judged to be scientifically advantageous for the region of model application, and resulted in improved model agreement with observations. A single Calpuff receptor was included for each monitoring site.

The iterative procedure resulted in a final set of Calmet/Calpuff input conditions which yielded very good agreement with observations. All of the predicted/observed ratios fell within the factor-of-two criteria suggested by EPA.

Source Inventory

The evaluation analysis accounted for all SO_2 sources located within a reasonable distance of the two monitoring sites, and which operated during Year 2000. The inventory included all significant SO_2 sources within 250 km of the sites. Oil and gas production sources (i.e., treaters and flares) were also included. But because of their greater number and smaller size, the modeled inventory of oil and gas sources was limited to those located within 50 km of each monitoring site.

SO_2 sources included in the evaluation analysis are identified in Table 1. Source locations with respect to monitoring sites are depicted in Figure 1 (oil and gas source locations not shown).

SO_2 emission rates and stack operating parameters (i.e., exit velocity and temperature) were based on CEM's hourly data for Year 2000 where available. For significant sources with no CEM's data, constant emission rates and operating parameters reflecting annual average operation for Year 2000 were utilized. Annual average stack data for oil and gas production sources were derived from monthly production data for Year 2000. The emission characterization for each source is indicated in Table 1. As shown in Table 1, hourly emissions data were available for a majority of significant sources, and for most of the largest sources.

Emission rates for oil and gas production sources were derived from the ND State Industrial Commission's Oil and Gas data base. The oil and gas sources were screened to eliminate those with zero or minimal emissions. Stack operating parameters for oil and gas production sources were derived using procedures described in the "Williston Basin Regional Air Quality Study" (1990), and modified using SCREEN3 (EPA screening model) adjustments for effective flare plume height and radiational heat loss.

Calmet Input Data

The location of the 10 km computational grid utilized by the NDDH for the Year 2000 analysis is represented in Figure 1. The grid is defined by eight vertical layers. Meteorological input data for Calmet was based on 32 surface stations, 5 upper-air stations, and 89 precipitation stations located in or near the computational grid. GOES ASOS satellite data were used to supplement surface observations for ceiling height and sky cover. All meteorological data were obtained from the National Climatic Data Center (surface and precipitation data), or Forecast Systems Laboratory (upper-air data). Geophysical data were developed using the USGS GTOPO30 data set for terrain elevations and the USGS Global data set for land use.

Processing of meteorological data relied on Earth Tech software, as well as supplemental software developed by NDDH for format conversions and missing data substitution. Methodology for meteorological data preparation is generally consistent with that described in "Calpuff Class I Area Analysis for Milton R. Young Generating Station" (Draft), 1999. That methodology was modified for the Year 2000 analysis largely because of the inclusion of GOES ASOS satellite data. Methodology specific to the Year 2000 analysis has been informally described, and will be formally documented in a future report. Note that the possibility/effect of alternative approaches to meteorological data preparation was not considered in the performance evaluation.

Processing of terrain and land use data was strictly objective, and relied exclusively on Earth Tech software. Note that the seasonal scheme for land use related parameters, which has been informally documented, is not incorporated in the final iteration of the performance evaluation, which provided the best agreement with observations. Rather, Calmet default parameters were assumed for the entire year.

Calmet/Calpuff Control File Settings

For the most part, Calmet and Calpuff input control file settings, as implemented by the NDDH, were consistent with IWAQM recommendations. However, extensive testing of Calmet output, with visual feedback (plotted data), suggested that adjustment to a limited number of IWQAM settings was required to achieve reasonable results for wind and mixing height fields. Further, the adjustment of a limited number of additional settings was found to provide better agreement with observations in the performance evaluation, and such changes were judged to be scientifically consistent.

Non-IWAQM settings utilized by the NDDH for Calmet and Calpuff control files, and which provided optimum agreement with monitored observations, are listed in Table 2. These Non-IWAQM settings are discussed below.

Calmet

IKINE - The inclusion of kinematic effects provided significantly better agreement of Calpuff results with monitored observations. From a scientific standpoint, it seems inconsistent for IWAQM to recommend wind adjustment using Froude number effects (IFRADJ), and not kinematic effects.

BIAS(NZ) - NDDH bias settings were developed through significant testing with visual feedback. The IWAQM recommendation provides neutral bias (between surface and upper-air data) for all vertical layers. In light of its testing, the NDDH does not believe it is reasonable to assume equal weighting of upper-air wind data with surface data at the lowest level, and to assume equal weighting of surface data with upper-air data at top levels.

LVARY - The NDDH felt it necessary to deploy this option to ensure that at least one station would always be available.

ZUPWND(2) - The NDDH was concerned that IWAQM was recommending a value of 1000 m while the model (Earth Tech) default is 2500 m, thus prompting the NDDH compromise value of 2000 m. But regardless of the selected value for this initial guess wind field input, subsequent wind field development should converge to the same result.

MNMDAV/ILEVZI - The NDDH found that IWAQM default values for these parameters, relating to spatial averaging of mixing heights, produced entirely unacceptable results for the mixing height field. Severe gradients (bull's eyes) in mixing height were observed in the immediate vicinity of meteorological stations, and a significant increase in the value of these input parameters was required to mitigate the anomaly. The NDDH notes that because MNMDAV is a function of grid cell size, IWAQM should specify "User Defines" for this parameter.

ZIMAX/ZIMAXW - Because the NDDH Calmet/Calpuff grid extends into the western part of the upper Great Plains, maximum mixing height was increased to 4000 m to be consistent with maximum mixing heights reported for this region (Holzworth, 1972).

<u>Calpuff</u>

MSPLIT - The option for puff splitting was recommended by John Irwin (EPA) when modeling source-receptor distances of 200 km or more, because of the tendency for Calpuff to otherwise overpredict at these distances. Deployment of this option also provided better agreement with observations.

MDISP - Use of dispersion coefficient option 2 provided significantly better agreement with observations. The NDDH also believes this selection is more consistent with the "state-of-the-art" in air quality modeling.

BCKO3 - Though the NDDH is utilizing the hourly file option for ozone background, the BCKO3 value is substituted by Calpuff when hourly data are missing. Based on local monitoring data, NDDH judged the IWQAM value of 80 ppb to be much higher than typical for North Dakota, and therefore reset the value to 30 ppb.

BCKNH3 - The NDDH value of 2 ppb reflects the annual average of local, unbiased monitoring data.

XSAMLEN - The NDDH set this value lower than the IWAQM recommendation, but notes that the only consequence for doing so would be extra computer time due to more puffs on the grid. The goal was to improve model resolution by increasing the number of puffs and decreasing mass per puff. Again, because this parameter is a function of grid cell size, the NDDH believes the recommended XSAMLEN value should be "User Defined".

XMAXZI - Value was increased to 4000 m for consistency with ZIMAX/ZIMAXW setting in Calmet.

Some other deviations from IWAQM guidance, which had no consequence for model predictions, were also involved in the NDDH implementation. These related to printed output options and parameters for the Lambert conformal map projection used by the NDDH.

Results

Results of the performance evaluation are summarized in Figure 2 for the Dunn Center monitoring site, and in Figure 3 for the TRNP South monitoring site. The Figures include quantile-quantile plots of the highest 50 predictions and observations for 3-hour and 24-hour averaging times. The plots include "factor-of-two" curves for assessing performance. Note that these results represent the final iteration of the performance evaluation process, as reflected by the control file settings in Table 2.

Inspection of the quantile-quantile plots in Figures 2 and 3 reveals that the capability of the NDDH Calpuff modeling system to reproduce observed SO_2 concentrations is very good. All predicted-to-observed ratios fall within the factor-of-two criteria suggested by EPA, and in most cases are much better. Though some of the 50 highest 24-hour averages at both monitoring sites were underpredicted, it appears the modeling system produces no systematic bias toward underprediction on overprediction when considering the ensemble results.

One caveat regarding these results in that TRNP South Unit monitoring data for Year 2000 included extensive missing periods (about 700 hours total). Therefore, maximum observations may be under-represented in the comparative analysis, moving the bias more toward underprediction, particularly for 24-hour averages.

Conclusions

The evaluation of Calpuff performance for Year 2000 data at Dunn Center and TRNP South Unit monitoring sites indicates the modeling system performs well, when implemented using IWAQM control file settings as modified by NDDH (Table 2). Predicted-to-observed ratios for the fifty highest predicted/observed concentrations fell within the factor-of-two criteria suggested by EPA, and did not exhibit systematic bias toward underprediction or overprediction. Therefore, the NDDH implementation of the Calpuff modeling system, using currently processed meteorological/geophysical data and IWAQM control file settings as modified by NDDH, should be acceptable for regulatory Class I area modeling in North Dakota.

The NDDH recognizes that minor improvement in model performance is still possible. But the implication of these performance evaluation results is that caution must attend any suggested changes to input or methodology. Changing all control file settings to IWAQM-recommended values, for example, would likely move some predicted-to-observed ratios outside of the factor-of-two window.

Table 1
Source Inventory (SO_2)

Source	Emission Characterization	Figure 1 Loc. Key
Coal Creek Station	Actual Hourly	1
Antelope Valley Station	Actual Hourly	2
Coyote Station	Actual Hourly	3
Leland Olds Station	Actual Hourly	4
Milton R. Young Station	Actual Hourly	5
Heskett Station	Actual Hourly	6
Stanton Station	Actual Hourly	4
Great Plains Synfuels Plant	Actual Hourly*	2
Little Knife Gas Plant	Actual Hourly	7
Grasslands Gas Plant	Actual Hourly	8
Tioga Gas Plant	Annual Average	9
Lignite Gas Plant	Annual Average	10
Mandan Refinery	Annual Average	6
Boundary Dam Station	Annual Average	11
Shand Station	Annual Average	12
Colstrip Station	Actual Hourly	13
CELP Boiler	Annual Average	14
Sidney Station	Annual Average	15
Oil & Gas Related**	Annual Average	–

* Hourly CEM's data were available for GPSP main stack only. Annual average emission assumed for other three units.

** All facilities located within 50 km of monitoring sites.

Table 2
Non-IWAQM Settings Used by NDDH
in Calmet/Calpuff Control Files

Parameter	IWAQM	NDDH
Calmet		
IKINE	0	1
BIAS(NZ)	0,0,0,0, 0,0,0,0	-1.0, -0.9, -0.7, 0.0, 0.5, 1.0, 1.0, 1.0
LVARY	F	T
ZUPWND(2)	1000 m	2000 m
MNMDAV	1	8
ILEVZI	1	4
ZIMAX	3000 m	4000 m
ZIMAXW	3000 m	4000 m
Calpuff		
MSPLIT*	0	1
MDISP	3	2
BCKO3	80 ppb	30 ppb
BCKNH3	10 ppb	2 ppb
XSAMLEN	1.0	0.5
XMAXZI	3000 m	4000 m

* Puff splitting was not deployed in Calpuff control file for oil and gas sources. This concession to model execution time is reasonable, because puffs would not grow very large given the maximum 50 km source-receptor distance.

Figure 1: Monitor and Source Locations

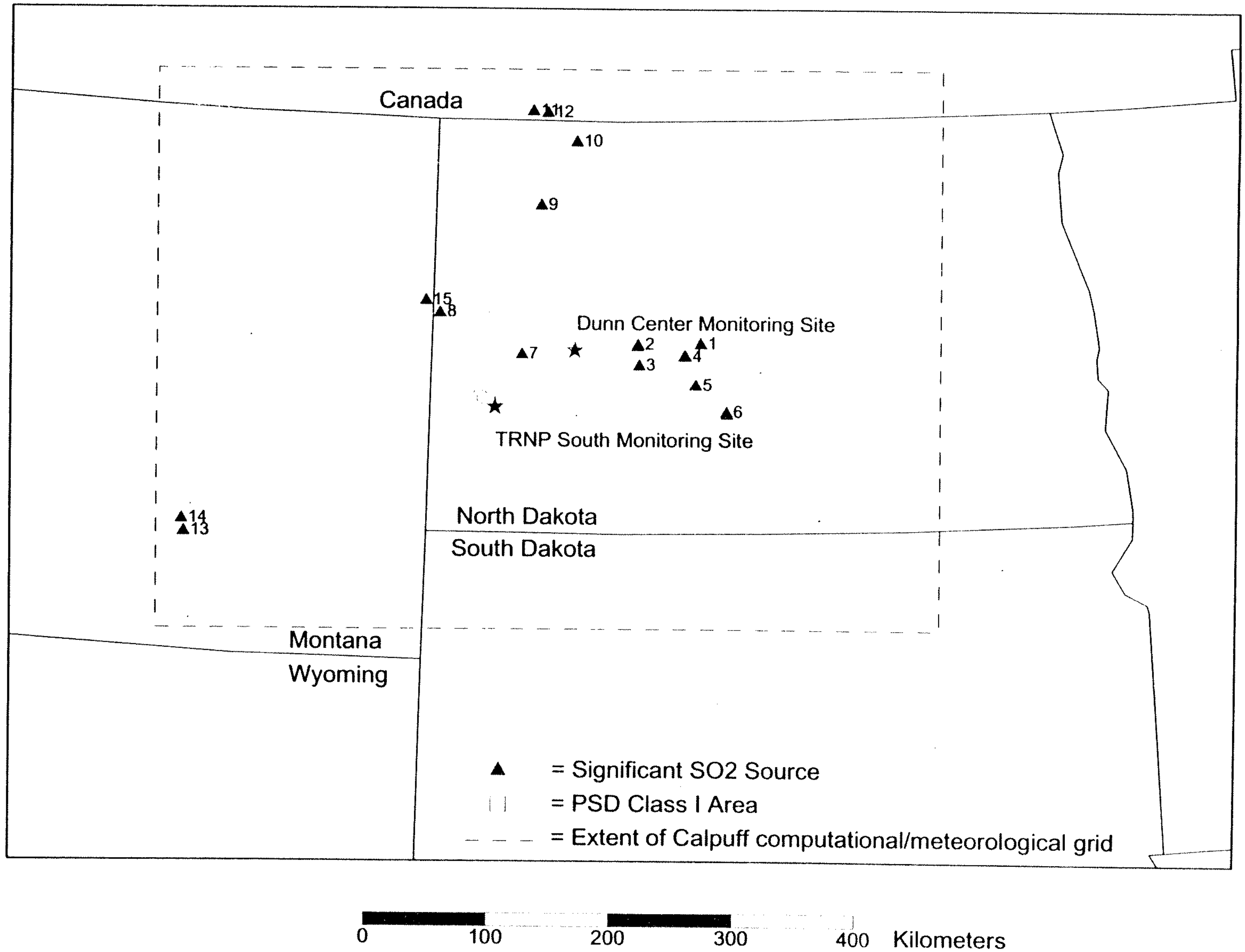
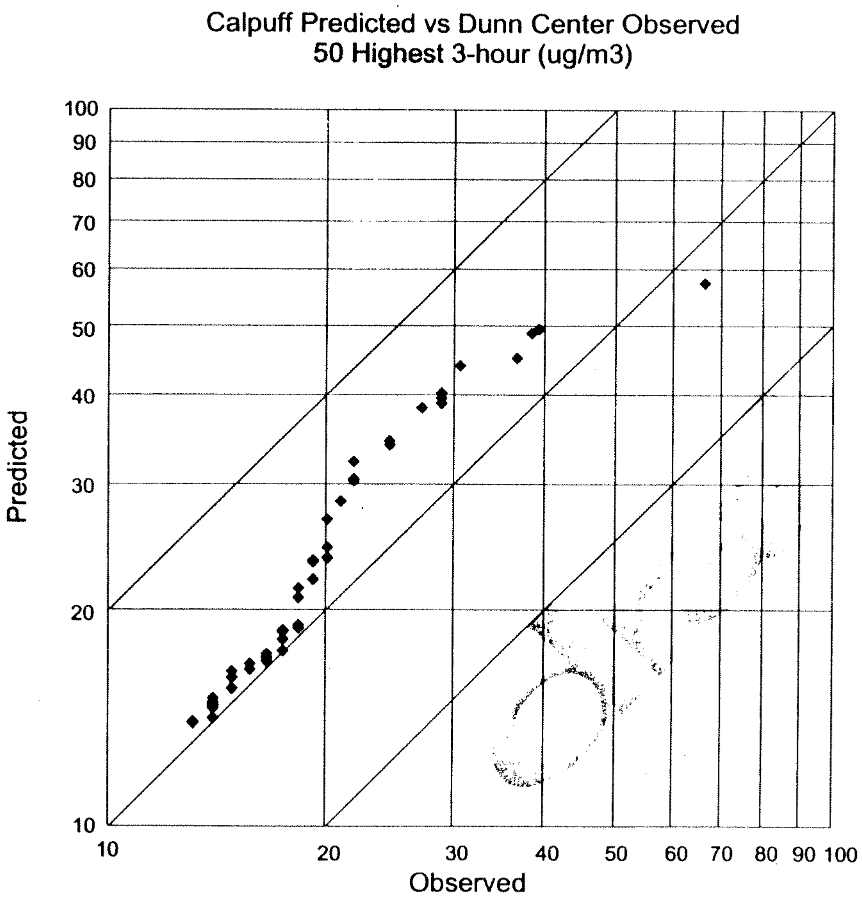
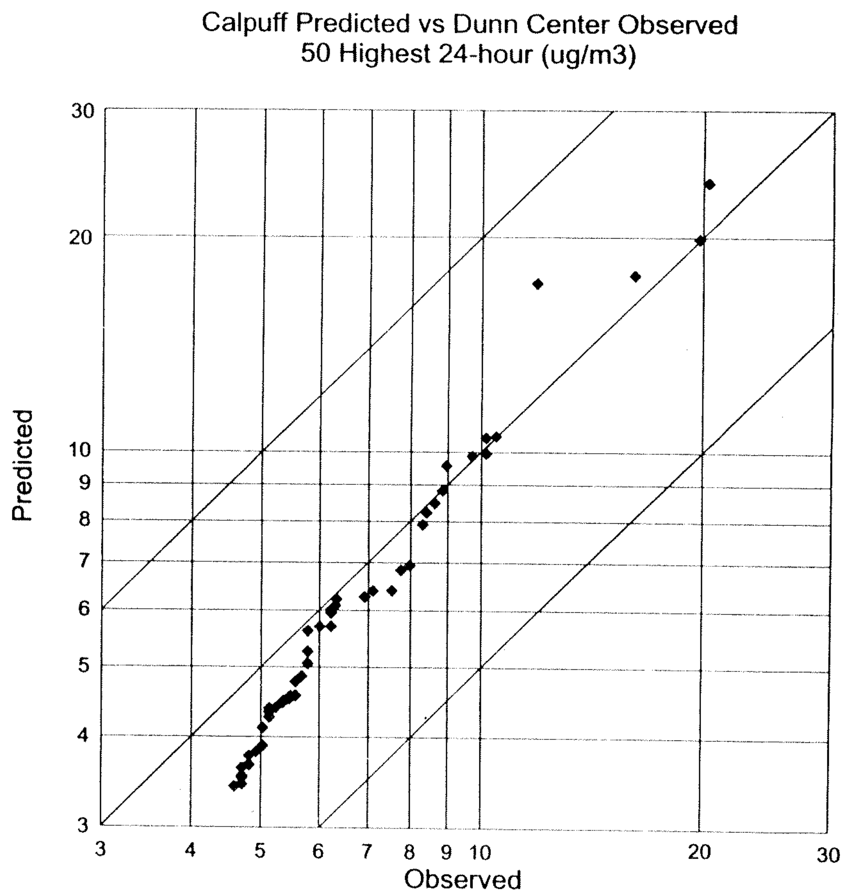


Figure 2


Calpuff Predicted vs Dunn Center Observed
50 Highest 3-hour (ug/m3)
100
90
80
70
60
50
40
30
20
10
Predicted
10
20
30
40
50
60
70
80
90
100
Observed


Calpuff Predicted vs Dunn Center Observed
50 Highest 24-hour (ug/m3)
30
20
10
9
8
7
6
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4
3
Predicted
3
4
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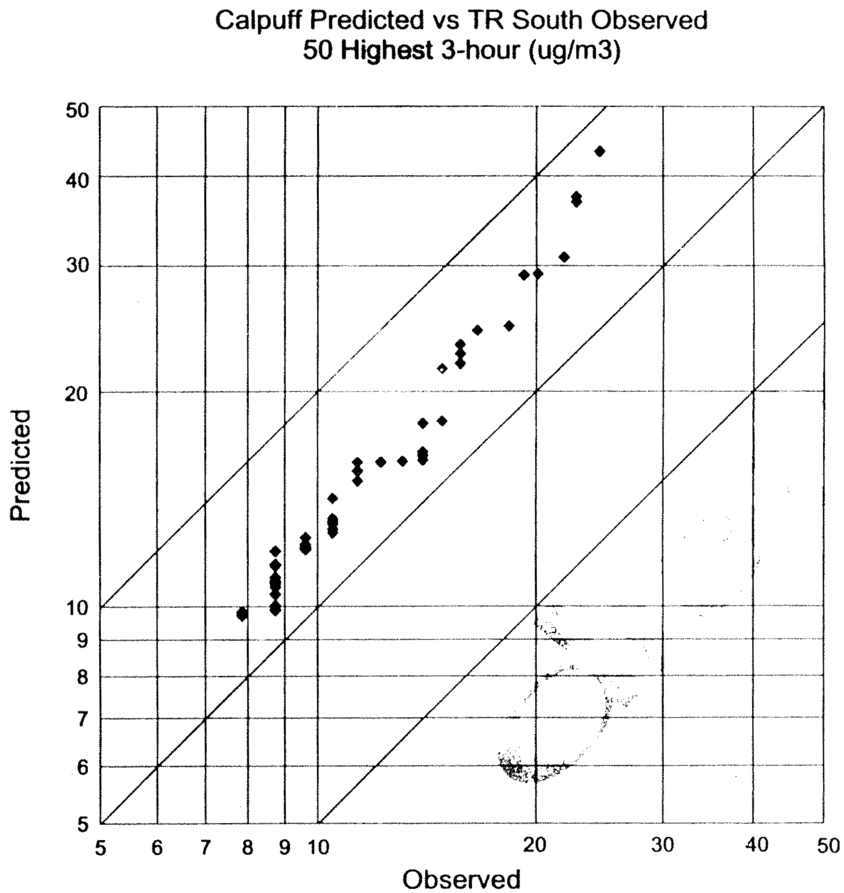
6
7
8
9
10
20
30
Observed

Figure 3


Calpuff Predicted vs TR South Observed
50 Highest 3-hour (ug/m3)
Predicted
Observed
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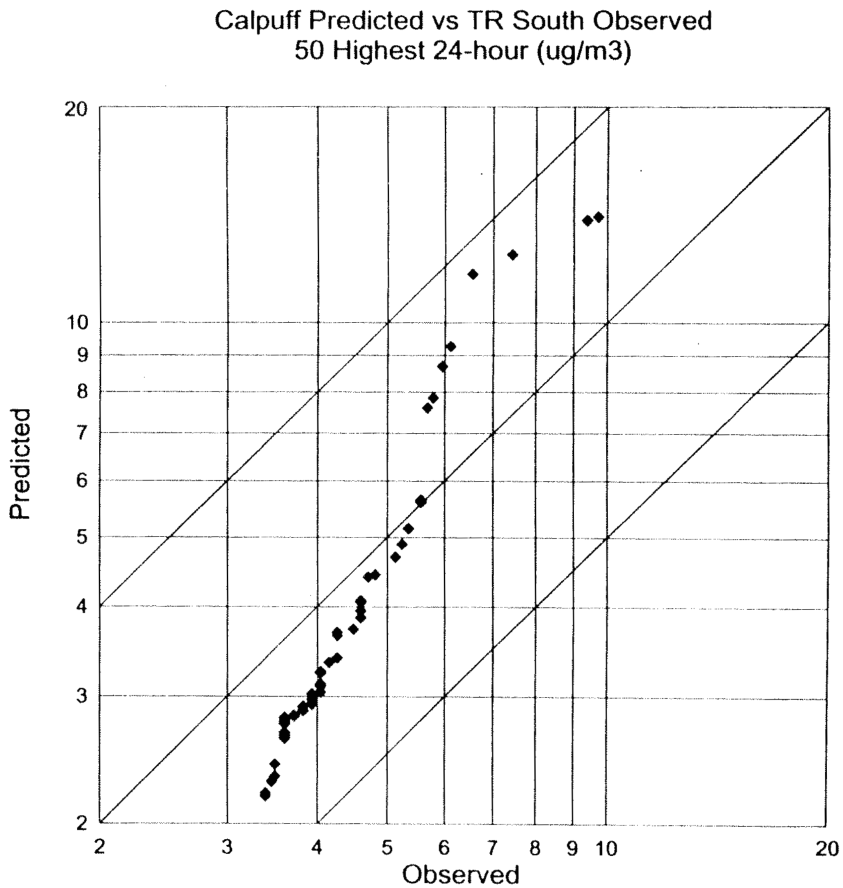
Calpuff Predicted vs TR South Observed
50 Highest 24-hour (ug/m3)
Predicted
Observed
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Appendix C

IWAQM Recommendations for Calmet Control File

Variable	Description	Value
GEO.DAT	Name of Geophysical data file	GEO.DAT
SURF.DAT	Name of Surface data file	SURF.DAT
PRECIP.DAT	Name of Precipitation data file	PRECIP.DAT
NUSTA	Number of upper air data sites	User Defined
UPn.DAT	Names of NUSTA upper air data files	UPn.DAT
IBYR	Beginning year	User Defines
IBMO	Beginning month	User Defines
IBDY	Beginning day	User Defines
IBHR	Beginning hour	User Defines
IBTZ	Base time zone	User Defines
IRLG	Number of hours to simulate	User Defines
IRTYPE	Output file type to create (must be 1 for CALPUFF)	1
LCALGRD	Are w-components and temperature needed?	T
NX	Number of east-west grid cells	**User Defines**
NY	Number of north-south grid cells	**User Defines**
DGRIDKM	Grid spacing	**User Defines**
XORIGKM	Southwest grid cell X coordinate	User Defines
YORIGKM	Southwest grid cell Y coordinate	User Defines
XLAT0	Southwest grid cell latitude	User Defines
YLON0	Southwest grid cell longitude	User Defines
IUTMZN	UTM Zone	User Defines
LLCONF	When using Lambert Conformal map coordinates, rotate winds from true north to map north?	F
XLAT1	Latitude of 1st standard parallel	**30**
XLAT2	Latituae of 2nd standard parallel	**60**

Variable	Description	Value
RLON0	Longitude used if LLCONF = T	**90**
RLAT0	Latitude used if LLCONF = T	**40**
NZ	Number of vertical layers	**User Defines**
ZFACE	Vertical cell face heights (NZ+1 values)	**User Defines**
LSAVE	Save met. data fields in an unformatted file?	T
IFORMO	Format of unformatted file (1 for CALPUFF)	1
NSSTA	Number of stations in SURF.DAT file	User Defines
NPSTA	Number of stations in PRECIP.DAT	User Defines
ICLOUD	Is cloud data to be input as gridded fields? (0 = No)	0
IFORMS	Format of surface data (2 = formatted)	2
IFORMP	Format of precipitation data (2 = formatted)	2
IFORMC	Format of cloud data (2 = formatted)	2
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1
IFRADJ	Adjust winds using Froude number effects? (1 = Yes)	1
IKINE	Adjust winds using kinematic effects? (1 = Yes)	0
IOBR	Use O'Brien procedure for vertical winds? (0 = No)	0
ISLOPE	Compute slope flows? (1 = Yes)	1
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4
ICALM	Extrapolate surface calms to upper layers? (0 = No)	0
BIAS	Surface/upper-air weighting factors (NZ values)	NZ*0

Variable	Description	Value
IPROG	Using prognostic or MM-FDDA data? (0 = No)	0
LVARY	Use varying radius to develop surface winds?	**F**
RMAX1	Max surface over-land extrapolation radius (km)	**User Defines**
RMAX2	Max aloft over-land extrapolation radius (km)	**User Defines**
RMAX3	Maximum over-water extrapolation radius (km)	**User Defines**
RMIN	Minimum extrapolation radius (km)	0.1
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to -1 if IEXTRP = ±4)	4
TERRAD	Radius of influence of terrain features (km)	**User Defined**
R1	Relative weight at surface of Step 1 field and obs	**User Defines**
R2	Relative weight aloft of Step 1 field and obs	**User Defines**
DIVLIM	Maximum acceptable divergence	5.E-6
NITER	Max number of passes in divergence minimization	50
NSMTH	Number of passes in smoothing (NZ values)	2, 4*(NZ-1)
NINTR2	Max number of stations for interpolations (NA values)	**99**
CRITFN	Critical Froude number	1
ALPHA	Empirical factor triggering kinematic effects	0.1
IDIOPT1	Compute temperatures from observations (0 = True)	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	**User Defines**
IDIOPT2	Compute domain-average lapse rates? (0 = True)	0
IUPT	Station for lapse rates (between 1 and NUSTA)	**User Defines**
ZUPT	Depth of domain-average lapse rate (m)	200

Variable	Description	Value
IDIOPT3	Compute internally inital guess winds? (0 = True)	0
IUPWND	Upper air station for domain winds (-1 = 1/r**2 interpolation of all stations)	-1
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1, 1000
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0
CONSTB	Neutral mixing height B constant	1.41
CONSTE	Convective mixing height E constant	0.15
CONSTN	Stable mixing height N constant	2400
CONSTW	Over-water mixing height W constant	0.16
FCORIOL	Absolute value of Coriolis parameter	1.E-4
IAVEXZI	Spatial averaging of mixing heights? (1 = True)	1
MNMDAV	Max averaging radius (number of grid cells)	1
HAFANG	Half-angle for looking upwind (degrees)	30
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1
DPTMIN	Minimum capping potential temperature lapse rate	0.001
DZZI	Depth for computing capping lapse rate (m)	200
ZIMIN	Minimum over-land mixing height (m)	50
ZIMAX	Maximum over-land mixing height (m)	3000
ZIMINW	Minimum over-water mixing height (m)	50
ZIMAXW	Maximum over-water mixing heigh (m)	3000
IRAD	Form of temperature interpolation (1 = 1/r)	1
TRADKM	Radius of temperature interpolation (km)	500

Variable	Description	Value
NUMTS	Max number of stations in temperature interpolations	5
IAVET	Conduct spatial averaging of temperature? (1 = True)	1
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098
TGDEFA	Default over-water capping lapse rate (K/m)	-0.0045
JWAT1	Beginning landuse type defining water	999
JWAT2	Ending landuse type defining water	999
NFLAGP	Method for precipitation interpolation (2 = 1/r**2)	2
SIGMAP	Precip radius for interpolations (km)	100
CUTP	Minimum cut off precip rate (mm/hr)	0.01
SSn	NSSTA input records for surface stations	User Defines
USn	NUSTA input records for upper-air stations	User Defines
PSn	NPSTA input records for precipitation stations	User Defines

Appendix D

IWAQM Recommendations

for Calpuff Control File

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Variable	Description	Value
METDAT	CALMET input data filename	CALMET.DAT
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST
CONDAT	Filename for output concentration data	CONC.DAT
DFDAT	Filename for output dry deposition fluxes	DFLX.DAT
WFDAT	Filename for output wet deposition fluxes	WFLX.DAT
VISDAT	Filename for output relative humidities (for visibility)	VISB.DAT
METRUN	Do we run all periods (1) or a subset (0)?	0
IBYR	Beginning year	User Defined
IBMO	Beginning month	User Defined
IBDY	Beginning day	User Defined
IBHR	Beginning hour	User Defined
IRLG	Length of run (hours)	User Defined
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5
NSE	Number of species emitted	3
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0
METFM	Format of input meteorology (1 = CALMET)	1
AVET	Averaging time lateral dispersion parameters (minutes)	60
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1
MCTADJ	Terrain adjustments to plume path (3 = Plume path)	3
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0
MSLUG	Near-field puff treatment (0 = No slugs)	0

Variable	Description	Value
MTRANS	Model transitional plume rise? (1 = Yes)	1
MTIP	Treat stack tip downwash? (1 = Yes)	1
MSHEAR	Treat vertical wind shear? (0 = No)	0
MSPLIT	Allow puffs to split? (0 = No)	**0**
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1
MWET	Model wet deposition? (1 = Yes)	1
MDRY	Model dry deposition? (1 = Yes)	1
MDISP	Method for dispersion coefficients (3 = PG & MP)	3
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3
MROUGH	Adjust PG for surface roughness? (0 = No)	0
MPARTL	Model partial plume penetration? (0 = No)	1
MTINV	Elevated inversion strength (0 = compute from data)	0
MPDF	Use PDF for convective dispersion? (0 = No)	0
MSGTIBL	Use TIBL module? (0 = No) allows treatment of subgrid scale coastal areas	0
MREG	Regulatory default checks? (1 = Yes)	1
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOX, HNO3, NO3)	**User Defined**
Specie Names	Manner species will be modeled	**User Defined**
Specie Groups	Grouping of species, if any.	**User Defined**
NX	Number of east-west grids of input meteorology	User Defined
NY	Number of north-south grids of input meteorology	User Defined
NZ	Number of vertical layers of input meteorology	User Defined

Variable	Description	Value
DGRIDKM	Meteorology grid spacing (km)	User Defined
ZFACE	Vertical cell face heights of input meteorology	User Defined
XORIGKM	Southwest corner (east-west) of input meteorology	User Defined
YORIGIM	Southwest corner (north-south) of input meteorology	User Defined
IUTMZN	UTM zone	User Defined
XLAT	Latitude of center of meteorology domain	User Defined
XLONG	Longitude of center of meteorology domain	User Defined
XTZ	Base time zone of input meteorology	User Defined
IBCOMP	Southwest X-index of computational domain	**User Defined**
JBCOMP	Southwest Y-index of computational domain	**User Defined**
IECOMP	Northeast X-index of computational domain	**User Defined**
JECOMP	Northeast Y-index of computational domain	**User Defined**
LSAMP	Use gridded receptors? (T = Yes)	F
IBSAMP	Southwest X-index of receptor grid	User Defined
JBSAMP	Southwest Y-index of receptor grid	User Defined
IESAMP	Northeast X-index of receptor grid	User Defined
JESAMP	Northeast Y-index of receptor grid	User Defined
MESHDN	Gridded recpetor spacing = DGRIDKM/MESHDN	1
ICON	Output concentrations? (1 = Yes)	1
IDRY	Output dry deposition flux? (1 = Yes)	1
IWET	Output west deposition flux? (1 = Yes)	1
IVIS	Output RH for visibility calculations (1 = Yes)	1
LCOMPRS	Use compression option in output? (T = Yes)	T

Variable	Description	Value
ICPRT	Print concentrations? (0 = No)	0
IDPRT	Print dry deposition fluxes (0 = No)	0
IWPRT	Print wet deposition fluxes (0 = No)	0
ICFRQ	Concentration print interval (1 = hourly)	1
IDFRQ	Dry deposition flux print interval (1 = hourly)	1
IWFRQ	West deposition flux print interval (1 = hourly)	1
IPRTU	Print output units (1 = g/m**3; g/m**2/s)	1
IMESG	Status messages to screen? (1 = Yes)	1
Output Species	Where to output various species	**User Defined**
LDEBUG	Turn on debug tracking? (F = No)	F
Dry Gas Dep	Chemical parameters of gaseous deposition species	**User Defined**
Dry Part. Dep	Chemical parameters of particulate deposition species	**User Defined**
RCUTR	Reference cuticle resistance (s/cm)	30.
RGR	Reference ground resistance (s/cm)	10.
REACTR	Reference reactivity	8
NINT	Number of particle-size intervals	9
IVEG	Vegetative state (1 = active and unstressed)	1
Wet Dep	Wet deposition parameters	**User Defined**
MOZ	Ozone background? (1 = read from ozone.dat)	1
BCKO3	Ozone default (ppb) (Use only for missing data)	**80**
BCKNH3	Ammonia background (ppb)	**10**
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2
RNITE3	Nighttime HNO3 loss rate (%/hr)	2

Variable	Description	Value
SYTDEP	Horizontal size (m) to switch to time dependence	550.
MHFTSE	Use Heffter for vertical dispersion? (0 = No)	0
JSUP	PG Stability class above mixed layer	5
CONK1	Stable dispersion constant (Eq 2.7-3)	0.01
CONK2	Neutral dispersion constant (Eq 2.7-4)	0.1
TBD	Transition for downwash algorithms (0.5 = ISC)	0.5
IURB1	Beginning urban landuse type	10
IURB2	Ending urban landuse type	19
Use Following Only For Single-Point Meteorological Input (CALPUFF Screen)		
ILANDUIN	Land use type (20 = Unirrigated agricultural land)	20
ZOIN	Roughness length (m)	0.25
XLAIIN	Leaf area index	3
ELEVIN	Met. Station elevation (m above MSL)	0
XLATIN	Met. Station North latitude (degrees)	**User Defined**
XLONIN	Met. Station West longitude (degrees)	**User Defined**
ANEMHT	Anemometer height of ISC meteorological data (m)	10.0
ISIGMAV	Lateral turbulence (Not used with ISC meteorology)	1
IMIXCTDM	Mixing heights (Not used with ISC meteorology)	0
End of Single Point Meteorology Input Variables		
XMXLEN	Maximum slug length in units of DGRIDKM	1
XSAMLEN	Maximum puff travel distance per sampling step (units of DGRIDKM)	1

Variable	Description	Value
MXNEW	Maximum number of puffs per hour	99
MXSAM	Maximum sampling steps per hour	99
SL2PF	Maximum Sy/puff length	10
PLX0	Wind speed power-law exponents	0.07,0.07,0.10,0.15,0.35,0.55
WSCAT	Upper bounds 1st 5 wind speed classes (m/s)	1.54,3.09,5.14,8.23.10.8
PGGO	Potential temperature gradients PG E and F (deg/km)	0.020, 0.035
SYMIN	Minimum lateral dispersion of new puff (m)	1.0
SZMIN	Minimum vertical dispersion of new puff (m)	1.0
SVMIN	Array of minimum lateral turbulence (m/s)	6*0.50
SWMIN	Array of minimum vertical turbulence (m/s)	0.20, 0.12, 0.08, 0.06, 0.03, 0.016
CDIV	Divergence criterion for dw/dz (1/s)	0.01
WSCALM	Minimum non-calm wind speed (m/s)	0.5
XMAXZI	Maximum mixing height (m)	3000
XMINZI	Minimum mixing height (m)	50
PPC	Plume path coefficients (only if MCTADJ = 3)	0.5,0.5,0.5,0.5,0.35,0.35
NSPLIT	Number of puffs when puffs split	3
IRESPLIT	Hours when puff are eligible to split	**User Defined**
ZISPLIT	Previous hour's mixing height (minimum), (m)	100
ROLDMAX	Previous Max mixing height/[illegible] mixing height ratio, must be less than this value to allow puff split	0.25

Variable	Description	Value
EPSSLUG	Convergence criterion for slug sampling integration	1.0E-04
PESAREA	Convergence criterion for area source integration	1.0E-06
NPT1	Number of point sources	User Defined
IPTU	Units of emission rates (1 = g/s)	1
NSPT1	Number of point source-species combinations	0
NPT2	Number of point sources with fully variable emission rates	0
Point Sources	Point sources characteristics	User Defined
Area Sources	Area sources characteristics	User Defined
Line Sources	Buoyant lines source characteristics	User Defined
Volume Sources	Volume sources characteristics	User Defined
NREC	Number of user defined receptors	User Defined
Receptor Data	Location and elevation (MSL) of receptors	User Defined